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TITLE OF THESIS/*TITRE DE LA THÈSE* A STUDY OF SOME VARIABLES RELATING TO TECHNOLOGICAL INNOVATION IN CANADA

UNIVERSITY/*UNIVERSITÉ* UNIVERSITY of ALBERTA

DEGREE FOR WHICH THESIS WAS PRESENTED/ *GRADE POUR LEQUEL CETTE THÈSE FUT PRÉSENTÉE* MASTER of BUSINESS ADMINISTRATION

YEAR THIS DEGREE CONFERRED/*ANNÉE D'OBTENTION DE CE GRADE* 1975

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A STUDY OF SOME VARIABLES RELATING TO TECHNOLOGICAL INNOVATION IN CANADA

by

© JOHN ADAMS WATSON

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF BUSINESS ADMINISTRATION

FACULTY OF BUSINESS ADMINISTRATION AND COMMERCE

EDMONTON, ALBERTA

FALL 1975

UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled, A STUDY OF SOME VARIABLES RELATING TO TECHNOLOGICAL INNOVATION IN CANADA, submitted by JOHN ADAMS WATSON in partial fulfillment of the requirements for the degree of MASTER OF BUSINESS ADMINISTRATION.

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Date . June 20, 1975.

ABSTRACT

This thesis examined the relationship between variables describing size, nationality of ownership, and sophistication in technological innovation. It also extended and supplemented the research project reported to the Federal Department of Industry, Trade, and Commerce by M. J. Dunn, B. M. Harnden, and P. M. Maher in May 1974 under the title "An Investigation Into the Climate for Technological Innovation in Canada". The data base resulting from the 1974 study was extended by the addition of size and ownership information for most of the participating firms. Analysis of the extended data base was carried out: (1) to ascertain the usefulness of size and ownership in segmenting firms according to their level of sophistication in technological innovation; (2) to identify the characteristics of firms forming the market for an experimental management development program for research and development project selection decision makers; and (3) to address some questions raised by the May 1974 report.

This study found that larger firms tended to be more sophisticated with respect to technological innovation than smaller firms and that nationality of ownership did not correlate with sophistication. Specifically, variables describing use of research and development project selection techniques, changes in corporate organization, use of technological forecasting,

experience with computerized decision information systems, and use of games or simulations in research and development project selection were found to correlate significantly with size. Larger firms tended to make more use of the techniques than smaller firms and had changed their corporate structure to a greater extent than smaller firms.

ACKNOWLEDGEMENTS

The author wishes to thank Professor W. H. Stewart for his advice in the final stages of this project, Professor M. J. Dunn for the assistance and helpful suggestions he made throughout, and Professor Boyd M. Harnden, without whose competent supervision and invaluable advice this thesis could not have been written.

To my wife and family, I express my gratitude for their support and encouragement throughout the program.

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CHAPTER I

INTRODUCTION

I. Introduction to the Study

This chapter presents an overview of the research project and discusses the rationale behind it in terms of its practical applications as well as its academic interest. The links between this study and a related project by M. J. Dunn, B. M. Harnden and P. M. Maher are explained and the objectives of this study are presented.

II. Overview

This study examines whether the size of a firm or the nationality of its owners has any effect on the firm's attitudes and practices with respect to technological innovation. In particular an attempt is made to determine whether the variables size and nationality of ownership are useful in segmenting firms according to their level of sophistication in the area of technological innovation.

Information describing the level of sophistication in firms was collected by M. J. Dunn, B. M. Harnden and P. M. Maher (all from the University of Alberta, Faculty of Business Administration and Commerce) as part of their

"Investigation Into the Climate for Technological Innovation in Canada".[1] Dunn et al. felt that a firm's level of sophistication in the area of technological innovation could be described by variables such as: use of research and development project selection techniques; changes to centralize or decentralize decision making; changes from line-staff to program management; use of technological forecasting; use of computerized decision information systems, and use of games or simulations in research and development project selection. In fact, Dunn et al. defined and collected information about 180 variables for their study of technological innovation. The variables listed above are those which were found to be germane to this study.

III. Rationale

Attempts to improve the level of sophistication among firms represented in the data collected by Dunn et al. either through the development of counselling and instructional programs, or through the direct expenditure of resources, would be expedited if the firms were segmented as follows:

1. According to their level of sophistication, so that the program could be reasonably succinct.

2. According to some variable which would provide a basis for deciding on level of support. For example, an expenditure of $20,000 would be expected to have much more impact on a small firm than a large firm in terms of seeding interest in improving the firm's

level of sophistication in technological innovation. For very large firms an expenditure of a different order of magnitude might be required.

3. According to the nationality of ownership, since expenditure of public resources might be sensitive to this factor.

In addition to these "practical" motives for developing size and ownership data, there are also academic interests in the matter. Intuitively one would expect size of firms to be an important variable to look at when considering ways of segmenting firms according to different levels of sophistication in the area of technological innovation. Without consulting the literature, one might recall two opposing points of view on the matter: the first is that sophistication in this area is expensive and thus only large firms can afford it, e.g., IBM Research, Bell Laboratories, etc...; the second is that innovation comes from the small entrepreneur who is free to be creative without worrying about corporate policy, internal politics, or layers of bureaucracy.[2] These viewpoints are to some extent contradictory and can be investigated by segmenting firms according to size and sophistication.

The question of foreign ownership of Canadian businesses is a cause célèbre at the present time and it is of interest to determine whether nationality of ownership makes any difference in a company's attitudes and actions with respect

to technological innovation. If foreign owned firms are more (or less) sophisticated than Canadian owned firms then the ramifications of this should be studied.

IV. The Dunn, Harnden, and Maher Study

The present study takes as its starting point the data base collected by Dunn et al. as part of their research program aimed at "the design and development of an experimental management development program for research and development project selection decisionmakers"[3]. The first phase of that program was reported to the Federal Department of Industry, Trade and Commerce in May 1974 in a report entitled "An Investigation Into the Climate for Technological Innovation in Canada"[4].

Dunn et al. noted that two major factors influenced their research:

> (1) the lack of empirical data with respect to decisionmaking in Canadian technologically based organizations, in particular the lack of data with respect to decisionmaking in the area of project selection and evaluation, and (2) the apparent need for a Canadian management development program aimed at increasing Canadian managers' skills in the use of modern decisionmaking techniques . . . .[5]

Their research program included three activities:

1. The collection and analysis of empirical data pertinent to the research objectives. (Collection was by means of an extensive questionnaire [see appendix A] mailed to all companies in Canada reporting research and

development activities as of the fall of 1973. Analysis was carried out using subroutines available in the Statistical Package for the Social Sciences[6] at the University of Alberta Computing Centre).

2. A review of the "state-of-the-art" of management games and simulations.

3. Interviews with a subset of those managers responding to the questionnaire.

The work of Dunn et al. was one of the first collections of empirical data about decision making in the area of research and development project selection and evaluation in Canada. Their data did not include information about the size or nationality of ownership of the responding firms.

V. Objectives

This study has as its objectives:

1. To ascertain whether the variables size and nationality of ownership are useful in segmenting firms according to their level of sophistication in the area of technological innovation.

2. To advance the work of Dunn et al. by identifying the characteristics of the firms forming the market for their experimental management development program.

3. To address the important questions raised in Clarke's[7] critique of the May 1974 report by Dunn et al. Clarke's questions are listed below:

a. How do Canadian owned and controlled firms compare with U.S. and other foreign owned firms with respect to the use of sophisticated management techniques in the area of research and development project selection decision making?[8]

b. Are new management techniques being adopted by smaller companies?[9]

VI. Summary

This study extends the data base collected by Dunn et al. to include size and ownership information for the responding firms. Analysis of the extended data base is carried out to ascertain the usefulness of the new variables in segmenting the firms in the data base according to their sophistication in technological innovation and to identify the characteristics of firms forming the market for an experimental management development program.

Notes for Chapter I

[1]M. J. Dunn and B. M. Harnden (in collaboration with P. M. Maher), An Investigation Into the Climate for Technological Innovation in Canada (Edmonton: An Unpublished Report Submitted to the Department of Industry, Trade, and Commerce, Ottawa, May 1974), p. 6.

[2]Ibid., p. 28.

[3]Ibid., p. 6.

[4]Ibid.

[5]Ibid., pp. 8-9.

[6]N. H. Nie, D. H. Bent, and C. H. Hull, Statistical Package for the Social Sciences. (U.S.A.: McGraw-Hill Ltd., 1970).

[7]Memorandum from T. E. Clarke, Ministry of State for Science and Technology, "Critique of Dunn and Harnden Report" (Confidential), July 24, 1974.

[8]Ibid.

[9]Ibid.

CHAPTER II

A REVIEW OF THE LITERATURE

A review of pertinent literature was made in order to ascertain what relationships might be expected to exist between the size and ownership of Canadian based firms and technological innovation. This chapter reports on the results of this review under the topic headings of Size, Ownership, Productivity and Structure.

I. Size

Literature references to the effects of size in determining the climate for technological innovation are not widespread. Wilkinson[1] noted studies by English, Eastman, Safarian and others which report the existence of "external economies" in highly industrialized areas, such as the U.S., West Germany, and Sweden. External economies, in this case, refers to specialized services available, higher than normal concentrations of suppliers, transportation terminals, etc. These factors produce advantages for entrepreneurs, which facilitate innovation and the realization of innovative processes. In addition,

in highly industrialized areas, concentrations of highly trained manpower exist which also facilitate the rapid commercialization of the results of the innovative process.

Wilkinson[2] discusses "dynamic scale economics" or "learn-by-doing" economies as postulated by Posner, Arrow, and Kaldor, noting that they suggest

> "that as a nation gains in production experience, it can produce more efficiently, so that greater output and hence lower unit costs are achieved from the same inputs. In essence, the dynamic economies attained mean that the nation's technology is ahead of that of other nations."[3]

Two important points can be made with respect to dynamic scale economies:

(1) they apply to "firms" as well as "nations"[4].

and

(2) the advantages they provide are irreversible, once obtained, so long as new products continue to be developed.[5]

Therefore, it might be expected that size of the firm and success in technological innovation are positively correlated, i.e., the larger the firm the greater the success in technological innovation. Remembering that the curve describing the life cycle of a product flattens at the top, the advantages noted above will be particularly true for firms where product cycles are overlapping and new product development is programmed in such a manner that product life cycles are longer than the time that it takes to "spin off" derivative products.

II. Ownership

Recent statistics published by the federal department of Industry Trade & Commerce[6] indicate foreign ownership of 37 percent of the assets of non-financial corporations in Canada in 1970. Foreign ownership in some sectors of the economy ranged much higher, for example, manufacturing was 59 percent foreign owned and parts of the oil industry were 99 percent foreign owned.

In recent years the question of foreign ownership has become an emotional and political issue in Canada. The Committee for an Independent Canada was formed in 1970 and claimed 25,000 members by 1972. The Federal Government and several Provincial Governments reacted to the pressure from the Committee for an Independent Canada and other groups by forming high level committees to study the question of foreign ownership. The reports of these committees provide some of the most complete documentation of the subject in existence. Examples of this include the Gray Report, the report of the Ontario Interdepartmental Task Force on Foreign Investment, and the Report of the Government of Alberta Select Committee on Foreign Investment. Consideration of the effects of ownership in determining the climate for technological innovation thus leads into an area characterized by both private and public concern.

Concern about foreign ownership of Canadian industry and its effects on technological innovation in Canada began at the turn of the century. At that time British investment was the source of concern. However, since World War I, and more particularly since 1957, interest has focussed on the effects of U.S. ownership of Canadian industry. For example, Dr. E. W. R. Steacie (President of the National Research Council) made the following statement to the Royal Commission on Canada's Economic Prospects (the "Gordon" Commission).

> There are two main factors which have affected the development of industrial research in Canada. In the first place in a pioneer country primary industries develop first and secondary industries come rather late into the picture. As a result good facilities for research in agriculture and in mining developed long before industrial research as such got going at all. This is the normal course of the development of research in a country as it becomes industrialized. The second factor is that because of the proximity of Canada to the United States and because of the financial relationship between Canadian and American (and British) firms, most Canadian plants are essentially branch plants and research is normally done by the parent organization outside the country. As a result Canadian industry has been largely dependent on research in the United States and in Britain. The result of this is that, by comparison with the United States or Britain, relatively little industrial research has been done in Canada by industrial organizations while a great deal has been done by Government agencies for the industry.[7]

Dr. Steacie's concern has been echoed more recently by Hurtig,[8] Lamontagne,[9] the Gray Report[10] and the Science Council of Canada.[11]

The general viewpoint in the literature cited above is that Canadian technological innovation suffers because of foreign ownership. It suggests that plants operating in Canada tend to be branch plants of the large U.S. Parent firms or "truncated" operations. The Gray report defined a truncated operation as an operation without a full range of company services, e.g., a field sales office. When a foreign firm considers all Canada to be "the field office" then Canada loses management jobs, research and development labs and decision making power. Branch plants import what is called component technology, i.e., just enough technology to establish plants scaled to the Canadian market. Some of these writers allege that Canadian managers are most often charged with innovating only to the extent necessary to maximize profits in Canada based on the standard U.S. product line (which may or may not be modified for Canadian conditions). There is general agreement that this discourages innovation by Canadian management and results in many missed opportunities in international markets. Research and development is primarily carried out at the U.S. head office while Canadian managers are merely told what to do and how to do it.

On the other hand, Safarian[12] found no statistical difference between the amount of research and development done by resident and non-resident owned firms. In addition, Wilkinson makes the point that

> . . . the non-resident owned firms may have access to the research results of their U.S. parents [this] suggests that they would have

> a larger store of knowledge to draw upon and consequently would be able to produce more innovations per dollar of additional research within Canada.[13]

If the findings of Safarian and Wilkinson are extrapolated one might expect there to be little difference in the level of technological innovation between foreign owned firms and Canadian owned firms except for that traceable to systematic size differences between countries. If a country's firms tended to be bigger than those of another country then the former's firms would have a "larger store of knowledge to draw upon" and Wilkinson's point might prevail.

III. Productivity

Recent studies sponsored by the Economic Council of Canada[14] have indicated that in the early 1970's prices and costs of comparable manufactured goods were typically higher in Canada than in the U.S. These price differentials reflected the fact that levels of output per person employed in the various sectors of Canadian industry were considerably lower than similar levels in the same sectors of the U.S. economy. This "productivity gap" has been the object of much scrutiny in recent years and was mentioned in a recent paper by D. J. Daly and Rein Peterson of York University[15]. Daly and Peterson addressed the question of the pattern of decision making in Canada. Their view was that Canadian managers have adopted a survival strategy characterized by resistance to change rather than innovation, creativity, and risk taking.[16]

Daly and Peterson reported that studies have shown that the level of real net national income per person employed in Canada was about 18.3 percent lower than the U.S. level. Differences in the quantity of factor inputs (capital, land and labour quality differences) accounted for only 0.7 percent. This is a relatively insignificant amount because the remaining difference in per capita income (17.6 percent) was not explainable by differences in all factor inputs. Daly and Peterson point out that this remaining gap in output per person employed can only be accounted for by the relative efficiency with which resources are being used by Canadian decision makers. Daly and Peterson suggest that an important factor in the productivity gap is "the relatively low level of professionalism practiced by Canadian management."[17] By this they mean the apparent lack of use of more sophisticated quantitative aids for decision making by Canadian managers. Daly and Peterson go on to state that this lower level of professionalism appears to be the result of:

> (1) a traditional decision making style that has not emphasized risk taking, entrepreneurship, nor scientific approaches to decision making,
>
> (2) a lack of formally trained, yet experienced decision makers who supplement their intuitive decision making style with rational, analytical approaches based on the scientific method, and
>
> (3) high tariff barriers . . . that have allowed these conditions to persist . . . .[18]

Economic Council of Canada Staff Study # 23 reports that productivity gaps exist between Canada and Europe and Canada and the United Kingdom, as well as between Canada and the U.S.A.:

> The share of growth associated with increases of factor productivity was smaller in Canada in the period 1950-1962 than in any of the other countries [U.S., Belgium, France, Germany, Netherlands, Denmark, Norway, United Kingdom, Italy].[19]

In fact 30 percent of Canadian GNP growth in that period was attributable to increased factor productivity as compared with 75 percent in N.W. Europe.[20]

The studies noted below link factor productivity or changes in factor productivity with technological innovation or related factors (e.g., industrial research and development). The Economic Council of Canada stated:

> In most industries, as at the national level, increases in factor productivity arise from a very wide range of influences such as improvements in technology.[21]

The Science Council of Canada noted that the difference in Canada versus U.S. manufacturing output is

> usually attributed to [among other things] . . . less efficient transfer of technology.[22]

Lamontagne (Volume I) noted that, while Canada has a relatively large professional labour force engaged in research and development activities, (see table 1), Canada's performance, as compared with that of nine other industrialized countries, has not been very good in terms of four indicators of technological

TABLE 1 QUALIFIED SCIENTISTS AND ENGINEERS (QSEs) IN RESEARCH AND DEVELOPMENT IN SEVEN OECD COUNTRIES, 1967[2 3]

Country	Total No. of QSEs in R & D	Total Civilian Labour Force Employed (000's)	QSEs in R & D as percent of Labour Force	Rank
U.S.A.	537,273	74,372	0.72	1
France	49,224	10,700*	0.46	2
Canada	19,350	7,379	0.26	3
Germany	61,559	25,803	0.24	4
Belgium	7,945	3,616	0.22	5
U.K.	50,345	24,509	0.21	6
Sweden	7,395	3,734	0.20	7

*ESTIMATED

innovation.[24] These four indicators are:

(1) Location of 100 significant innovations since 1945 (Canada ranks tenth).

(2) Monetary receipts for patents, etc., 1963 - 1964 (Canada ranks eighth).

(3) Number of patents taken out in foreign countries, 1963 (Canada ranks ninth).

(4) Export performance in Research intensive product groups, 1963 - 1965 (Canada ranks ninth).

In addition, Canada ranks tenth out of ten in the OECD composite ranking (see table 2) and it is a fact that Canadian industry performs less research and development than industry in most other advanced countries. This is shown in table 3.

In this study it was assumed that the responses to the original questionnaire could be interpreted as representing the parent companies' attitudes and practices with respect to technological innovation. If this assumption is correct, then, based on the review of the literature discussed above, one should expect to find that foreign owned companies have significantly different attitudes and practices with respect to technological innovation than Canadian owned companies. However, if the responses to the original questionnaire represent the attitudes and practices about technological innovation found in truncated, branch plant operations, then one might find that the correlations based on ownership are much less significant.

TABLE 2 FOUR PERFORMANCE INDICATORS OF TECHNOLOGICAL INNOVATION IN TEN INDUSTRIALLY ADVANCED COUNTRIES[25]

Indicators	I. Location of 100 Significant Innovations since 1945		II. Monetary Receipts for Patents etc., 1963-64		III. Number of Patents Taken Out in Foreign Countries, 1963		IV. Export Performance in Research-Intensive Product Groups 1963-65		Composite Index
Country	No.	Adjusted* Rank	$ million	Adjusted Rank	#'000	Adjusted Rank	% share	Rank	Rank
Belgium	1	5	7.9	5	1.8	10	3.0	10	8
Canada	0	10	6.2	8	1.9	9	2.0	9	10
France	2	8	46.3	4	9.3	6	6.5	8	6
Germany	14	4	49.4	7	29.9	2	21.1	2	3
Italy	3	7	9.9	9	4.6	7	5.7	6	7
Japan	4	9	5.9	10	3.5	8	5.9	7	9
Netherlands	1	6	26.0	1	6.4	5	5.9	5	5
Sweden	4	2	7.1	6	3.8	4	4.0	3	3
U.K.	18	3	76.1	3	15.2	3	13.9	4	2
U.S.A.	74	1	386.7	2	56.3	1	31.1	1	1

*Adjusted Rank--Makes Allowance for Differences in Size of Work Forces.

TABLE 3 DISTRIBUTION OF NATIONAL RESEARCH AND DEVELOPMENT EXPENDITURES BY SECTORS OF PERFORMANCE AND COUNTRY, 1967[26]

(Percentages)

	Business Enterprises	Government	Higher Education	Private Non-Profit
Switzerland	76.5	6.3	17.2	
Sweden	69.9	14.2	15.5	0.4
United States	69.8	14.5	12.1	3.6
Germany	68.2	5.1	16.3	10.4
Belgium	66.8	10.4	21.4	1.3
United Kingdom	64.9	24.8	7.8	2.5
Japan	62.5	13.0	22.9	1.6
Netherlands	58.1	2.7	17.7	21.5
France	54.2	32.1	12.9	0.8
Canada	37.7	35.6	← 26.7 →	

IV. Structure

Dunn, Harndén, and Maher described the structure of organizations in terms of five fundamental components: hierarchy, data base, goals, controls and people attitudes.[27] They argued that these elements of structure are not changed whimsically by management and that they represent the slowest changing parts of the corporation. Thus, from the point of view of developing an experimental management development program for research and development project selection decision makers,

> accurate knowledge about the rate of changes of structure, particularly the nature of the trend towards or away from centralization, is important because the allocation of resources to research and development projects is made at different levels . . . of hierarchical organizations. Assessment of the impact of change in organizational structure is important in understanding the resource allocation process.[28]

Whisler's position is supportive and specific:

> . . . the most successful manager is one who very early perceives . . . trends just beginning to develop . . . and then devises and implements an effective adaptation for the organization.[29]

Whisler sees management as a "mediating force adapting an organization to the world".[30] Thus, businesses change, and they change because:

> surviving and thriving in this dynamic and complex world is chiefly a matter of perceiving the need to adapt in time to make the appropriate adjustments.[31]

One may, therefore, hypothesize that changes in structure represent attempts by management to adapt to the changing business environment and that this would be one indicator of management's willingness to adopt technological innovation.[32]

V. Summary

The general conclusions drawn from the literature review are summarized below.

A. Size

The works of Wilkinson, English, Eastman and Safarian all pointed to a positive correlation between sophistication in technological innovation and large size.

B. Ownership

The literature did not provide a clear indication of the type of relationship between ownership and sophistication in technological innovation. While a number of authors expressed concern about foreign ownership and its effects on technological innovation, the empirical studies by Safarian, and the statements by Wilkinson did not support this concern.

C. Productivity

Based on the work of Daly and Peterson and the reports from the Economic Council of Canada, the

Science Council of Canada, and the Lamontagne Committee, the results should show a relationship between foreign ownership and sophistication in technological innovation. This relationship depends upon the assumption that "the answers on the questionnaire reflect the attitudes and practices of the parent companies in the area of technological innovation." It may be that the answers on the questionnaire reflect the attitudes and practices of truncated, branch plant operations. If such is the case, then the correlation between owership and sophistication in technological innovation may not be evident.

D. Structure

Based on Dunn, Harnden, and Maher's report and Whisler's book, a hypothesis was developed which predicted a correlation between changes in structure and willingness to adopt technological innovation.

Notes for Chapter II

[1]B. W. Wilkinson, Canada's International Trade: An Analysis of Recent Trends and Patterns (Canada: The Canadian Trade Committee of the Private Planning Association of Canada, Feb., 1968), p. 109.

[2]Ibid., p. 114.

[3]Ibid.

[4]Wilkinson makes this substitution himself (Ibid., p. 115).

[5]Ibid., p. 115. For a single product there is a diminishing advantage with both time and volume.

[6]Annual Report of the Minister of Industry, Trade, and Commerce under the Corporations and Labour Unions Returns Act (Part I, Corporations), 1970, (Short Title: Calura), (Ottawa: Statistics Canada, March, 1973), pp. 16, 21, 120.

[7]Dr. E. W. R. Steacie, quoted in Safarian (A. E. Safarian, Foreign Ownership of Canadian Industry (Toronto: McGraw-Hill Canada Ltd., 1966).

[8]M. G. Hurtig, "A Submission to the Select Committee on Foreign Ownership of the Government of Alberta", (Edmonton: Unpublished, Dec., 1972).

[9]Hon. Sen. M. Lamontagne (Chairman), A Science Policy for Canada, Report of the Senate Special Committee on Science Policy, (Short Title: Lamontagne Report) (3 Vols., Ottawa: Queen's Printer, 1970, 1972, 1973).

[10]Hon. H. Gray (Chairman), Foreign Direct Investment in Canada (Short Title: The Gray Report), (Ottawa: Information Canada, 1972).

[11]Innovation in a Cold Climate: The Dilemma of Canadian Manufacturing, Report No. 15, The Science Council of Canada (Ottawa: Information Canada, 1971).

[12]Safarian, op. cit.

[13]Wilkinson, op. cit., p. 131.

[14]D. J. Daly, B. A. Keys, and E. J. Spence, Scale and Specialization in Canadian Manufacturing, Staff Study 21, Economic Council of Canada (Ottawa: Queen's Printer, 1968), and E. C. West, Canada-U.S. Price and Productivity Differences in Manufacturing Industries, 1973 Staff Study 32, Economic Council of Canada (Ottawa: Queen's Printer, 1971).

[15]D. J. Daly, R. Peterson, op. cit.

[16]Ibid., p. 550.

[17]Ibid., p. 551.

[18]Ibid.

[19]D. Walters, Canadian Income Level and Growth: An International Perspective, Staff Study 23, Economic Council of Canada (Ottawa: Queen's Printer, 1971), p. 47.

[20]Fifth Annual Review, Economic Council of Canada (Ottawa: Queen's Printer, 1968), p. 20.

[21]Seventh Annual Review, Economic Council of Canada (Ottawa: Queen's Printer, 1970), p. 11.

[22]Report #15, The Science Council of Canada, op. cit., pp. 25-26.

[23]Ibid., p. 138.

[24]Lamontagne, op. cit., Vol. I, p. 135.

[25]Ibid., p. 135.

[26]Ibid., p. 128.

[27]Dunn, Harnden, and Maher, op. cit., p. 92, gives definitions. For purposes of this study, the key component of structure is Hierarchy which they define as "how the firm is organized". This study focusses on changes in Hierarchy represented by trends towards greater centralization or decentralization.

[28]Dunn, Harnden, and Maher, op. cit., p. 114.

[29]T. L. Whisler, Information Technology and Organizational Change (Belmont, California: Wadsworth Publishing Company, 1970), p. 7.

[30]Ibid.

[31]Ibid.

[32]B. M. Harnden, in private communication with the author.

CHAPTER III

METHODOLOGY AND DATA

This chapter reports on the data base resulting from the study by Dunn et al., the sources of size and ownership data, and the limitations of the data collected. The chapter also provides a description of the data base, gives a data profile, and describes the procedures used to analyze the data base. Finally, the statistical basis for accepting or rejecting correlations is explained.

I. The Dunn et al. Data Base

In collecting data for this study, the starting point was an examination of the 196 useable questionnaires which were the primary inputs to the study by Dunn et al. Dunn et al. mailed questionnaires to 550 companies doing business in Canada which had reported research and development activity to the Department of Industry, Trade, and Commerce as of the fall of 1973.

The Dunn et al. report noted that 84 percent of the responding firms were located in Ontario and Quebec and that none of the firms were located in the Maritimes. This indicated a bias in the sample[1] since

lack of response from Maritime firms resulted in a gap in the geographical representation of businesses in the data base.

Dunn et al. also found that 73 percent of the respondents represented top management. This was taken as an indication that the answers given on the questionnaire accurately represent corporate practice.

The questionnaires were examined manually and the name, location and type of business for each responding firm were noted.

II. Ownership

Ownership data was primarily obtained by means of a manual search of the Statistics Canada publication Intercorporate Ownership[2] and, to a lesser extent, publications such as Financial Post Survey of Mines (Oils and Industrials) for 1970, Dun and Bradstreet, and other business publications.

The bulk of the data was obtained from the Statistics Canada publication and the characteristics and limitations found therein govern this part of the data.

A. Limitations of Ownership Data

Statistics Canada defines control of a firm in terms of ownership of shares, and in Intercorporate Ownership a company is said to be foreign controlled if more than 50 percent of the voting rights of a company are held outside Canada and/or by one or more

Canadian companies which are in turn foreign controlled. The whole of the company is assigned to the country meeting the definition of control.

It is widely known that control can be exercised through ownership of less than 50 percent of the shares of a company, particularly if the company's shares are widely held. In addition, the exercise of licensing and franchise agreements may provide control without apparent ownership.

The difficulties of examining each corporation's affairs for signs of minority control or ironclad licensing or franchise agreements were insurmountable in a study such as this. In addition, it was not clear that such an examination would significantly improve the accuracy of results, since one would expect that cases of minority foreign control would be to some extent offset by cases of minority Canadian control. As a result, it was decided to use the Statistics Canada decision rule with respect to defining foreign ownership and, consequently, the terms "foreign ownership" and "foreign control" are interchangeable in this study.

Another limitation of the Statistics Canada data was its age. Ownership data was collected during the summer of 1974 using the latest Statistics Canada figures which were based on 1969 data (published in

November, 1971). Foreign ownership has increased significantly in the period 1969 to 1974[3] and more up-to-date information might have indicated a greater degree of foreign ownership among firms in the sample.

Finally, ownership information was not generally available for the smaller firms in the sample. Statistics Canada collects and publishes ownership data about companies with assets of more than $250,000.00 and/or sales in excess of $500,000.00 annually. Very small firms, i.e., firms with sales less than $500,000.00 annually, have thus been systematically excluded from this study, and it may be assumed that almost all the firms for which no ownership data was found belong to this group.

B. Results of the Collection of Ownership Data

Out of the 196 useable responses to the initial questionnaire, ownership data was obtained for 161 firms in the data gathering portion of this study.

III. Size

Size data for the year 1972 was gathered by means of a manual search of various financial publications available to the public at large, including: Dun & Bradstreet, Moody's, Financial Post Surveys, and similar publications. Since the data was collected in the summer and fall of 1974, the last complete year for which accurate information was consistently available was 1972.

It was assumed that, for purposes of this study, the "size" of a firm was represented by published sales figures for 1972.

A. Limitations of Size Data

In some cases sales data was not available for subsidiary firms but, instead, aggregate figures were given for the parent firms. It was assumed that this tended to occur most often in the case of closely held subsidiaries. The sales figures for the parent firm were employed in such cases since it was assumed that the attitudes and practices with respect to technological innovation would be those of the parent company.

B. Results of the Collection of Size Data

1972 sales figures were obtained for 146 out of the 196 responding firms.

IV. The Data Base

Data obtained from the questionnaires in the study by Dunn et al. had previously been converted into digital codes and entered on computer cards for machine processing. The deck was arranged by company, with three data cards per company. The sales and owner-

ship data for each company were entered on a fourth data card and inserted into the deck in the appropriate places, (see example of data deck--appendix B). Full sales and ownership data was available for 141 firms and partial data for 146 (sales) or 161 (ownership). The full data base then contained up to 182 separate pieces of information (variables) about each company (see appendix C for variable list).

V. Procedure

The data was first examined manually to gain a rough feeling for its quality, range and distribution. Based on that examination sales figures were grouped into four categories as follows:

Annual Sales	Category	Code
$1 Million - $60 Million	Small	1
$61 Million - $200 Million	Medium	2
$201 Million - $999 Million	Large	3
$1 Billion and Greater	Extra Large	4

The data deck was then examined using the subroutine "CODEBOOK" from the Statistical Package for the Social Sciences (SPSS)[4] and the IBM 360-67 at the University of Alberta Computing Centre.

VI. Data Profile

The companies were found to be manageably distributed by the initial, arbitrary, size allocations, with small firms accounting for 32 percent of the sample, medium

firms 18 percent, large 31 percent, and extra large 19 percent (see table 4). The firm distribution as to ownership was 50 percent U.S., 8 percent United Kingdom, 39 percent Canadian, less than 1 percent other Western OECD, and 2 percent "Unidentifiable" (not to be confused with the 35 firms for whom no ownership data was found) (see table 5).

It should be noted that if the 35 firms left out of the analysis because no ownership data was found were assumed to be Canadian owned, then the proportions became as follows: U.S. 41.3 percent, United Kingdom 6.6 percent, Canadian 49.5 percent, other Western OECD 0.5 percent, Unidentifiable 2.0 percent. It is important to note that comparison of this assumed distribution with that published by the Minister of Industry Trade and Commerce under the Corporations and Labour Unions Returns Act (CALURA)[5] showed that the sample used in this study approximated the true situation in Canada, i.e., Calura (1970) reported equity in Canadian non-financial corporations was distributed as follows: U.S. 34 percent, Other foreign 9 percent, Canadian 52 percent, Other (Unidentifiable) 5 percent. Thus, while the sample chosen by Dunn et al. for the original survey was limited to firms reporting research and development activities in 1973, the data base which resulted (and thus under-

TABLE 4 PROFILE DATA:--SALES IN 1972

Sales Volume ($'000,000)	Size	Absolute Frequency #	Relative Frequency* %	Cumulative Frequency %
1 - 60	Small	47	32.2	32.2
61 - 200	Medium	26	17.8	50.0
201 - 999	Large	45	30.8	80.8
1,000 +	Extra Large	28	19.2	100.0
Totals		146	100.0	

*Missing data not tabulated.

TABLE 5 PROFILE DATA:--OWNERSHIP IN 1969

Country of Ownership	Absolute Frequency #	Relative Frequency* %	Cumulative Frequency %
United States	81	50.0	50.0
United Kingdom	13	8.0	58.0
Other Western OECD	1	0.5	58.5
Unidentifiable	4	2.0	60.5
Canada	62	39.5	100.0
Totals	161	100.0	

*Missing data not tabulated.

lying the present study) was probably representative of the Canadian population of firms with respect to distribution of ownership.

However, the assumption that missing data should be equated to Canadian ownership (and small size) was too weak for this study and it was decided to undertake the analysis using only the part of the data base which was complete.

Analysis then proceeded to the next step, which was the preparation of crosstabulations.

VII. Crosstabulations

The original Dunn et al. questionnaire was examined to determine which variables would likely shed light on the questions under consideration and a preliminary crosstabulating run was done using the SPSS subroutine "CROSSTAB"[6] to crosstabulate the sales and ownership data with each other and also with seventy-eight of the other variables in the data base for each company.

A. Crosstab Subroutine

The crosstabulating subroutine in the SPSS package provides a joint frequency distribution of cases according to two or more chosen variables. The subroutine analyzes the joint frequency distributions statistically by means of significance tests. In this

case significance was determined by means of a Chi square test of association. The test is of the independence of two variables, and indicates the likelihood of having a distribution as different from statistical independence by chance alone as the observed distribution. In this analysis the cutoff chosen was a significance of 0.1 or less. In other words, a significant correlation was felt to exist between two variables if the joint frequency distribution had less than a 10 percent chance of resulting from two independent distributions.

The Chi square test carried out was, in fact, an "adjusted" Chi square. This test is automatically adjusted to account for the effects of empty cells in the matrix or cells with a low number of events. In cases where some doubt as to the validity of the initial test existed, additional runs were carried out wherein one of the variables (Ownership) was redefined to exclude empty cells and emphasize the crosstabulation between overlapping pairs of events. The results of these paired correlations are reported in Chapter IV.

VIII. Summary

This chapter has explained the sources, strengths and weaknesses of the data base, given a profile of the new data, and provided an explanation of the statistical methods used in the analysis of results.

Firms in Central Canada were found to be over-represented in the original sample while firms from the Maritimes were excluded. Since the original questionnaires tended to be answered by top management, the responses were assumed to be a reliable reflection of corporate practice.

Size and ownership data was found for approximately 75 percent of the 196 firms forming the original sample; however, very small firms are probably not accurately represented in the data base since information about them was not collected by Statistics Canada or the other sources consulted.

Notes for Chapter III

[1] CALURA (op. cit., p. 61) shows firms in Ontario and Quebec earned 70 percent of the taxable income among non-financial firms in Canada in 1970. In practice this figure is likely low when extrapolated to the number of firms, since Ontario has the vast majority of manufacturing firms while the resource industry in Alberta skews the income figures westward.

[2] Intercorporate Ownership, 1969, Statistics Canada, (Ottawa: Queen's Printer, November, 1971).

[3] Hurtig, op. cit., p. 19.

[4] Nie, Bent, Hull, op. cit., p. 102.

[5] CALURA, op. cit.

[6] Nie, Bent, Hull, op. cit., p. 116.

CHAPTER IV

ANALYSIS AND DISCUSSION

Analysis of the significant crosstabulations was carried out to ascertain the nature of the correlations, their consistency with respect to the literature, and their relevance to the objectives of the study. This chapter reports the results of that analysis under major headings which correspond to the "Objectives" noted in Chapter I, (p. 5).

For the purposes of this study, answers to the questionnaire were converted to simple "yes" or "no" responses, i.e., several questions which asked whether techniques had been used:--"for the past 2 years"; "for the past 2-5 years"; "for longer than 5 years"; "have never used"--were converted to: have used: "yes"; "no".

I. Size and Ownership

This section reports the results of an examination of the significant crosstabulations relating to size and ownership. The analysis was carried out with a view to determining the usefulness of the variables size and ownership in segmenting the firms according to their level of sophistication in technological innovation. In cases where the validity of the adjusted Chi square test was in doubt (e.g., there were some empty cells or cells with a low number of events), additional tests were carried out wherein the variable

"Ownership" was redefined to exclude empty cells and to increase the power of the test.

A. Analysis

The crosstabulations revealed significant correlations between size and eight of the 181 variables in the data base, and between ownership and one of the variables in the data base. For purposes of analysis, it was convenient to group the results according to the chapter headings used by Dunn et al. in their May 1974 report (Section five, below, was an exception to this format).

1. Research and Development Project Selection (See questionnaire [appendix A] question 12).

As shown in table 6 "Sales" and "Use of Research and Development Project Selection Techniques" were found to be correlated at the 0.0589 level of significance (p=.059). Examination of table 6 reveals that a higher proportion of large and extra large firms tended to make use of these techniques than small and medium firms.

2. Structural Change in Canadian Organizations Doing Research and Development (See questionnaire [appendix A] questions 20 and 21).

The variable "Sales" correlated significantly with "More Centralization" (p=.028) (table 7), "More Decentralization" (p=.070) (table 8), and "Change from Line-Staff to Program Management" (p=.007) (table 9). Examination of the tables reveals that larger firms have tended to change their structure while smaller firms

TABLE 6 CROSSTABULATION OF "SALES" AND "USE OF RESEARCH AND DEVELOPMENT PROJECT SELECTION TECHNIQUES"

Sales		Yes Firms	%	No Firms	%	Total Firms
Small	Firms	25	27.5	17	41.5	42
	%	59.5		40.5		31.8
Medium	Firms	15	16.5	10	27.4	25
	%	60.0		40.0		18.9
Large	Firms	28	30.8	11	26.8	39
	%	71.8		28.2		29.5
Extra Large	Firms	23	25.3	3	7.3	26
	%	88.5		11.5		19.7
Total	Firms	91		41		132
	%	68.9		31.1		100.0

Chi Square 7.448
Degrees of Freedom 3

Significance 0.0589 (Variables: 181 x 060)

TABLE 7 CROSSTABULATION OF "SALES" AND "MORE CENTRALIZATION"

Sales		Change Firms	%	No Change Firms	%	Totals Firms
Small	Firms	11	20.4	23	46.0	34
	%	32.4		67.6		32.7
Medium	Firms	9	16.7	9	18.0	18
	%	50.0		50.0		17.3
Large	Firms	22	40.7	11	22.0	33
	%	66.7		33.3		31.7
Extra Large	Firms	12	22.2	7	14.0	19
	%	63.2		36.8		18.3
Total	Firms	54		50		104
	%	51.9		48.1		100.0

Chi Square 9.0773
Degrees of Freedom 3

Significance 0.0283 (Variables: 181 x 113)

TABLE 8 CROSSTABULATION OF "SALES" AND "MORE DECENTRALIZATION"

		Change Firms	%	No Change Firms	%	Total Firms
Small	Firms	9	23.1	24	46.2	33
	%	27.3		72.7		36.3
Medium	Firms	7	17.9	11	21.2	18
	%	38.9		61.1		19.8
Large	Firms	15	38.5	10	19.2	25
	%	60.0		40.0		27.5
Extra Large	Firms	8	20.5	7	13.5	15
	%	53.3		46.7		16.5
Total	Firms	39		52		91
	%	42.9		57.1		100.0

Chi Square 7.0607
Degrees of Freedom 3
Significance 0.0700

(Variables: 181 x 114)

TABLE 9: CROSSTABULATION OF "SALES" AND "CHANGE FROM LINE-STAFF TO PROGRAM MANAGEMENT"

		Change Firms	%	No Change Firms	%	Total Firms
Small	Firms	6	17.6	21	39.6	27
	%	22.2		77.8		31.0
Medium	Firms	7	20.6	10	18.9	17
	%	41.2		58.8		19.5
Large	Firms	8	23.5	17	32.1	25
	%	32.0		68.0		28.7
Extra Large	Firms	13	38.2	5	9.4	18
	%	72.2		27.8		20.7
Total	Firms	34		53		87
	%	39.1		60.9		100.0

Chi Square 12.0853
Degrees of Freedom 3

Significance 0.0071 (Variables: 181 x 115)

have tended not to change.

The variable "Ownership" correlated with "More Centralization" (p=.114) (table 10). A paired correlation was then carried out by separating the "Ownership" variable into three parts ("U.S. or Canada", "U.K. or Canada", and "U.S. or U.K."), and re-running the crosstabulation with respect to "More Centralization". Table 11 shows that the pair "U.S. or U.K." was significantly correlated with the variable "More Centralization" (p=.073). Analysis of table 10 reveals that firms owned in the United Kingdom have tended to change their structure to a lesser extent than firms owned in the United States. Correlations with respect to Canadian owned firms were not significant.

3. Technological Forecasting (See questionnaire [appendix A] question 26).

Table 12 shows that "Sales" and "Use of Technological Forecasting" were correlated at the 0.0678 level of significance. Analysis reveals that smaller firms tended to report that they had not used the technique while larger firms reported that they had used it.

4. Management Games or Simulations (See questionnaire [appendix A] questions 30-33).

"Sales" correlated significantly with "Experience in Computerized Decision Information Systems" (p=.002)(table 13) and "Games Used in Research and Development Project

TABLE 10 CROSSTABULATION OF "OWNERSHIP" AND "MORE CENTRALIZATION"

		Change Firms	%	No Change Firms	%	Total Firms
U.S.A.	Firms	38	62.3	25	47.2	63
	%	60.3		39.7		55.3
U.K.	Firms	2	3.3	7	13.2	9
	%	22.2		77.8		7.9
Canada	Firms	20	32.8	21	39.6	41
	%	48.8		51.2		36.0
Unidentified	Firms	1	1.6	0	0	1
	%	100.0		0		0.9
Total	Firms	61		53		114
	%	53.5		46.5		100.0

Chi Square 5.95261
Degrees of Freedom 3

Significance 0.1139 (Variables: 182 x 113)

TABLE 11 SIGNIFICANCE TABLE FOR PAIRED CORRELATIONS

BASIC CROSSTABULATION: OWNERSHIP IN 1969 BY MORE CENTRALIZATION

Owners in 1969	Significance of Crosstabulation with Respect to: More Centralization
U.S.A. or Canada	.3393
U.K. or Canada	.2789
U.S.A. or U.K.	.0730

(Variables: 182 x 113)

TABLE 12 CROSSTABULATION OF "SALES" AND "USE OF TECHNOLOGICAL FORECASTING"

		Yes		No		Total
		Firms	%	Firms	%	Firms
Small						
	Firms	14	24.1	27	36.0	41
	%	34.1		65.9		30.8
Medium						
	Firms	7	12.1	17	22.7	24
	%	29.2		70.8		18.0
Large						
	Firms	23	39.7	17	22.7	40
	%	57.5		42.5		30.1
Extra Large						
	Firms	14	24.1	14	18.7	28
	%	50.0		50.0		21.1
Total						
	Firms	58		75		133
	%	43.6		56.4		100.0

Chi Square 7.1322
Degrees of Freedom 3

Significance 0.0678 (Variables: 181 x 149)

TABLE 13 CROSSTABULATION OF "SALES" AND "EXPERIENCE IN COMPUTERIZED DECISION INFORMATION SYSTEMS"

		Yes		No		Total
		Firms	%	Firms	%	Firms
Small	Firms	2	6.3	38	39.2	40
	%	5.0		95.0		31.0
Medium	Firms	4	12.5	16	16.5	20
	%	20.0		80.0		15.5
Large	Firms	16	50.0	28	28.9	44
	%	36.4		63.6		34.1
Extra Large	Firms	10	31.3	15	15.5	25
	%	40.0		60.0		19.4
Total	Firms	32		97		129
	%	24.8		75.2		100.0

Chi Square 14.905
Degrees of Freedom 3

Significance 0.0019 (Variables: 181 x 168)

Selection" (p=.033) (table 14). Analysis shows that, while most firms had responded negatively to these questions, the firms which had responded positively tended to be proportionally more common in the large or extra large groups.

5. Size and Ownership

Table 15 shows that "Sales" and "Ownership" are significantly correlated (p=.008). Results of paired correlations (table 16) show significant correlations between "Sales" and the pairs "U.S. or Canada" (p=.002) and "U.K. or Canada" (p=.046). Analysis of table 15 shows that small firms tended to be Canadian owned, large and extra large firms tended to be owned in the United States, and firms owned in the United Kingdom tended to be medium and large.

B. Discussion

The crosstabulations reported thus far in this study have provided evidence which supports the view that large and extra large firms tend to be more sophisticated than small firms. Support for this view was manifested as follows:

1. Larger firms tended to make more use of research and development project selection techniques, a basic indicator of sophistication which Dunn, Harnden, and Maher treated in chapter IV of their report.[1]

2. Structural changes have taken place in proportionally more large firms than small firms. In chapter II of this

TABLE 14 CROSSTABULATION OF "SALES" AND "GAMES USED IN RESEARCH AND DEVELOPMENT PROJECT SELECTION"

		Yes		No		Total
		Firms	%	Firms	%	Firms
Small	Firms	2	10.5	43	35.0	45
	%	4.4		95.6		31.7
Medium	Firms	3	15.8	22	17.9	25
	%	12.0		88.0		17.6
Large	Firms	6	31.6	38	30.9	44
	%	13.6		86.4		31.0
Extra Large	Firms	8	42.1	20	16.3	28
	%	28.6		71.4		19.7
Total	Firms	19		123		142
	%	13.4		86.6		100.0

Chi Square 8.7190
Degrees of Freedom 3
Significance 0.0333 (Variables: 181 x 171)

TABLE 15 CROSSTABULATION OF "SALES" AND "OWNERSHIP"

Sales		Country U.S.A. Firms	%	U.K. Firms	%	Other OECD Firms	%	Canada Firms	%	Unident Firms	%	Total Firms
Small	Firms	16	21.1	1	8.3	1	100.0	25	50.0	1	50.0	44
	%	36.4		2.3		2.3		56.8		2.3		31.2
Medium	Firms	11	14.5	5	41.7	0	0.0	8	16.0	1	50.0	25
	%	44.0		20.0		0.0		32.0		4.0		17.7
Large	Firms	27	35.5	4	33.3	0	0.0	13	26.0	0	0.0	44
	%	61.4		9.1		0.0		29.5		0.0		31.2
Extra Large	Firms	22	28.9	2	16.7	0	0.0	4	8.0	0	0.0	28
	%	78.6		7.1		0.0		14.3		0.0		19.9
Total	Firms	76		12		1		50		2		141
	%	53.9		8.5		0.7		35.5		1.4		100.0

Chi Square 26.895
Degrees of Freedom 12

Significance 0.008

(Variables: 181 x 182)

TABLE 16 SIGNIFICANCE TABLE FOR PAIRED CORRELATIONS

BASIC CROSSTABULATION: OWNERSHIP IN 1969 BY SALES IN 1972

Owners in 1969	Significance of Crosstabulation with Respect to: Sales in 1972
U.S.A. or Canada	.0017
U.K. or Canada	.0463
U.S.A. or U.K.	.1288

(Variables: 182 x 181)

study, it was hypothesized that such changes are one indicator of management's willingness to adopt technological innovation.

3. The variables "Use of Technological Forecasting", "Experience in Computerized Decision Information Systems" and "Games Used in Research and Development Project Selection" are all indicators of sophistication which tended to be associated with larger firms to a significantly greater extent than with smaller firms.

In summary, seven of the variables in this section were significantly correlated with "Size". Analysis of these significant correlations revealed differences between small/medium firms and large/extra large firms which tend to support the findings noted in the review of the literature, that large size and sophistication are positively associated.

"Ownership" was found to be correlated with only one variable relating to sophistication in technological innovation--"More Centralization". In fact a paired correlation showed that firms owned in the United States had changed to a more centralized structure to a significantly greater extent than had firms owned in the United Kingdom.

"Ownership" was also significantly related to "Size", and the question arose: if "Size" and variables relating to sophistication were significantly correlated, and, if "Size" and "Ownership" were also significantly correlated, then why

was "Ownership" not significantly correlated with variables relating to sophistication?

One possible answer to this question is that foreign owned firms may be less sophisticated than average among the larger group, while Canadian owned firms may be more sophisticated than average among the smaller group. Cross-tabulation with respect to "Ownership" alone would not likely reveal a significant correlation between "Ownership" and sophistication. Other possible answers relate to the validity of the assumption that attitudes and practices reported in the questionnaire reflect those of the parent firm. The correlation between "Size" and "Ownership" warrants further study.

The general result with respect to determining the usefulness of the variable ownership in segmenting firms according to their level of sophistication in technological innovation was that no significant correlations were found to exist between variables describing country of ownership and level of sophistication.

II. Characteristics of the Firms

The overall aim of the Dunn, Harnden, and Maher research project is the development of an experimental management development program for Canadian businesses. Identification of the characteristics of firms forming the market for such a program is the focus of this section.

A. Analysis

1. Size Profile

Table 15 shows that out of 50 Canadian owned firms for which size and ownership data was collected, 25 had annual sales between one and 60 million dollars, eight had annual sales between 61 and 200 million dollars, 13 had annual sales between 201 and 999 million dollars, and four had annual sales of one billion dollars or more. Canadian firms represented 56.8 percent of the firms in the "small" category.

2. Sophistication and Size

The analysis carried out in section I of this chapter showed that small and medium firms tended to be less sophisticated with respect to technological innovation than large and extra large firms. In the following section the characteristics of firms in the sample are grouped according to firm size so that the market for the program is segmented according to that variable.

(a) "Small" Firms

Canadian owned firms make up 57.0 percent of the small category (table 15). The characteristics of firms in this category which were revealed in the significantly correlated crosstabulations are as follows:

(1) Small firms tended not to use research and development project selection techniques (table 6) to the same extent as larger firms.

(2) Proportionally fewer small firms had changed their structure (tables 7, 8, and 9).

(3) They tended not to use technological forecasting, computerized decision information systems, or games in research and development project selection to the same extent as larger firms (tables 12, 13, and 14).

(4) Table 17 reveals that 23 small firms agreed to participate further in the Dunn, Harnden, and Maher program. The small group thus represents 29.5 percent of the 78 firms agreeing to continue with the program.

In summary, the small firms in the sample tended to be less sophisticated than the larger firms, but tended to be about as interested as the average of firms in continuing with the program. Canadian owned firms dominated this category.

(b) "Medium" Firms

Canadian owned firms comprised eight of the 25 firms in this category. The characteristics of firms in the medium category which were revealed in the significantly correlated crosstabulations are as follows:

(1) Although 60 percent of the medium firms used research and development project selection techniques, this was much less common use of the techniques than among the larger firms and slightly less than the average for all firms (table 6).

(2) Analysis of tables 7, 8, and 9 reveals that changes in structure have occurred about as frequently among medium firms as the average for all firms in the sample. This was, however, less frequent than among large firms in the sample.

TABLE 17 CROSSTABULATION OF "SALES" AND "GAME PARTICIPATION CONSENT"

		Yes		No		Total
		Firms	%	Firms	%	Firms
Small	Firms	23	29.5	14	31.8	37
	%	62.2		37.8		30.3
Medium	Firms	18	23.1	3	6.8	21
	%	85.7		14.3		17.2
Large	Firms	21	26.9	19	43.2	40
	%	52.5		47.5		32.8
Extra Large	Firms	16	20.5	8	18.2	24.
	%	66.7		33.3		19.7
Total	Firms	78		44		122
	%	63.9		36.1		100.0

Chi Square 6.71636
Degrees of Freedom 3

Significance 0.0815 (Variables: 181 x 180)

(3) While use of technological forecasting was less common among medium firms than the average for the sample (table 12), use of computerized decision information systems and games in research and development project selection were about as common among medium firms as the average for all firms in the sample and less common than for the larger firms.

(4) Medium firms agreed to participate further in the study to a much greater extent than the average and were, in fact, 85.7 percent in favour of further participation.

In summary, medium sized firms were about as sophisticated as the "average" firms in the sample although they are less sophisticated than the larger firms. The large majority of medium firms are interested in further participation in the program.

(c) "Large" Firms

Canadian owned firms represented 29.5 percent of the firms in this category. The characteristics of the firms in the large category which were revealed in the significant crosstabulations are as follows:

(1) Use of research and development project selection techniques was slightly more common in this group than the average for all firms in the sample (table 6).

(2) Proportionally more firms in the large category have changed their structure (tables 7 and 8). An exception to this is found in table 9, wherein 32.0 percent of large firms had changed from "Line-Staff" to "Program" management compared to the sample average of 39.1 percent.

(3) Use of technological forecasting, experience in computerized decision information systems, and use of games in research and development project selection tended to be proportionally more common among larger firms than the sample average (tables 12, 13 and 14).

(4) Large firms were proportionally least interested in continuing with the research program (table 17).

In summary, as measured by this study, large firms tended to be more sophisticated than average and least interested in continuing with the program.

(d) "Extra Large" Firms

The profile of the large firms may be summarized by reporting that in all the categories used above, extra large firms tended to be above the sample average, i.e., in their use of research and development project selection techniques, in structural change, in use of sophisticated techniques and computers, and in their interest in continuing with the Dunn, Harnden, and Maher project. Firms owned in the United States formed 78.6 percent of the extra large group.

B. Discussion

The analysis has provided a tabulation of the characteristics of firms in each size category. The experimental management development program of Dunn et al. can thus be "tailored" to suit one or more particular size of firm. The results displayed in table 17 indicate that medium sized firms should receive high priority for implementation of the next step of the program. Their high degree of

interest in continuing with the program (85.7 percent in favour) provides an indication of corporate interest. In addition, the medium sized group tended to be about average in terms of sophistication and thus, since the management development program will also be a measuring device for assessing sophistication, provides a measure of the "average" level of sophistication of Canadian business.

III. Important Questions

The third objective of this study was to address the important questions raised in Clarke's critique of Dunn, Harnden, and Maher's report.[2]

A. How do Canadian owned and controlled firms compare with U.S. and other foreign owned firms with respect to the use of sophisticated management techniques in the area of research and development project selection?

The analysis carried out earlier in this chapter showed that the crosstabulations revealed no significant correlation with respect to ownership which bears on this question. In other words Canadian owned firms are not significantly different to firms owned in other countries with respect to their use of sophisticated management techniques. That result was tempered by the fact that

small firms were found to be less sophisticated than large firms and Canadian owned firms dominated the small group while foreign owned firms dominated the larger groups.

B. Are new management techniques being adopted by smaller companies?

Results of the crosstabulations indicated that smaller firms were not as sophisticated as larger firms. However, among the smaller firms use of some techniques is not uncommon, e.g., research and development project selection techniques were reportedly used in approximately 60 percent of both small and medium firms in the sample while use of technological forecasting was reported by 34.1 percent of small firms in the sample.

IV. Summary

In this chapter the significant results were displayed in tabular form and analyzed to determine the nature of the correlations, their consistency with respect to the literature, and their contribution to the objectives of the study.

The crosstabulations with respect to "Size" showed correlations between "Size" and other variables which, upon analysis, provided support for the view expressed in the literature (and noted in chapter II of this study), that sophistication in technological innovation and large size are associated.

Clarke's question concerning adoption of new techniques by smaller firms was addressed by this analysis. It is important to note that use of some of these sophisticated management techniques is not uncommon among smaller firms despite the fact that, in general, smaller firms were less sophisticated than larger firms.

The review of the literature noted that studies by Safarian and Wilkinson had not found any correlation between ownership and sophistication in technological innovation. The results of this study tended to sustain that finding since no direct correlation was found to exist between ownership and sophistication in technological innovation.

A significant correlation was found to exist between "Size" and "Ownership" and this, when coupled with the correlation between "Size" and sophistication, led to some speculation as to why "Ownership" and sophistication were not correlated. Additional study of this area is clearly warranted.

Notes for Chapter IV

[1]Dunn, Harnden, and Maher, op. cit., p. 57.

[2]Clarke, op. cit.

CHAPTER V

SUMMARY

This study was designed to examine the relationship between variables describing size, ownership, and sophistication in technological innovation and to extend and supplement the research project of Dunn, Harnden, and Maher which had as its overall objective: the design and development of an experimental management development program for research and development project selection decision makers. This chapter reviews the objectives of this portion of the project, the extent to which those objectives have been achieved in this study, and suggests areas for additional research.

I. Objectives

The objectives of this portion of the project were:

1. To ascertain whether size and ownership are useful in segmenting firms according to their level of sophistication in technological innovation.
2. To identify the characteristics of the firms forming the market for an experimental management development program.
3. To address the important questions raised in Clarke's critique of the May 1974 report by Dunn, Harnden, and Maher.

II. Summary of Results

1. Size and Ownership

Significant correlations were found to exist between size and variables relating to sophistication in the area of technological innovation. Analysis of the data revealed differences between the smaller firms and the larger firms with respect to sophistication which tended to justify the statement that larger firms tended to be more sophisticated than smaller firms. No important significant correlations were found to exist between variables describing country of ownership and level of sophistication.

2. Characteristics of Canadian Firms

The data was tabulated in such a way as to segment the characteristics of firms according to size. This form of segmentation seemed appropriate in view of the finding that size is an important variable in separating firms of different levels of sophistication (as defined by variables such as: use of research and development project selection techniques; changes to centralize or decentralize decision making; changes from line-staff to program management; use of technological forecasting; use of computerized decision information systems; and use of games or simulations in research and development project selection). Analysis in this section of the study indicated that medium sized firms should receive highest priority for the implementation of the next phase of the program (the design and development of an experimental management development pro-

gram for research and development project selection decision makers), since:

(a) the medium sized firm had the highest level of interest in continuing with the program and,

(b) the medium sized firms were about "average" in terms of sophistication and, since the experimental management development program will also be a measuring device for assessing level of sophistication, will provide a measure of the average level of sophistication of Canadian businesses.

3. Responses to Clarke's Questions

The important questions raised by Clarke in his critique of the Dunn et al. study were addressed. In summary, the addition of size and ownership data to the data base did not provide evidence that Canadian owned firms are significantly different to firms owned in the United States with respect to the use of sophisticated management techniques. However, the fact that small firms were found to be less sophisticated than larger firms and the correlation between size and ownership lead to a tempering of that result and a suggestion that additional study of this matter may be warranted.

III. Questions Raised by This Study

Two important questions are raised by the results of the Size and Ownership analysis. The first question was noted in chapter IV, section I (page 53) and is repeated here for sake of clarity:

If size and sophistication were significantly correlated and if size and ownership were significantly correlated, why then were ownership and sophistication not significantly correlated? Possible answers to this question were suggested in chapter IV; one relating to the distribution of firms with respect to sophistication within the size groupings; the other relating to the validity of the underlying assumption that attitudes and practices reported in the questionnaire reflect those of the parent firm. Additional study of this matter is recommended.

The second important question raised by the results is: why is there a difference in sophistication between smaller firms and larger firms? Phrased slightly differently: why aren't smaller firms as sophisticated as larger firms?

Larger firms employ sophisticated management techniques to help optimize decision making and thereby maximize profits. What can be said about smaller firms and sophisticated management techniques?

It seems likely that smaller firms would fit into one of five patterns:

1. Some smaller firms are (successfully) using sophisticated management techniques.
2. Some smaller firms have decided to use sophisticated management techniques but have been unable to implement them.

3. Some smaller firms have made rational and accurate economic decisions not to use the techniques.

4. Some smaller firms are not aware of the existence of the techniques and do not use them for that reason.

5. Some smaller firms have made decisions not to use the techniques because of prejudices, fear, erroneous analysis, etc.

The analysis of the size and ownership data carried out in this study has shown that significantly fewer smaller firms than larger firms fall into pattern 1 above. Some additional research is required to determine what proportion of smaller firms fall into patterns 2, 3, 4 and 5 respectively, and to identify the firms concerned for purposes of further analysis.

Firms falling into pattern 3 should be analyzed to see why use of the sophisticated management techniques is not economical and to determine whether it is reasonable to try to modify the firms and/or the techniques to make their use economically feasible.

Research should be undertaken to determine why firms in pattern 2 have not been successful in implementing the techniques and to ascertain ways of resolving the problems so that the new methods can be implemented. Several problem areas seem likely to exist:

1. Financial Constraints

There may be a threshold size below which firms are unable to afford the direct costs of using the techniques (e.g., cost of computers, salaries of analysts, etc.).

2. Manpower Constraints

The supply of persons trained in the use of these techniques may be a limiting factor.

3. Structural Constraints

The structure of some smaller firms (e.g., goals, control systems, hierarchy, data base, and people attitudes) may mitigate against introduction of sophisticated management techniques.

Research should be undertaken to pinpoint the problems of firms falling into patterns 4 and 5 to determine the most effective methods of providing education and assistance to resolve them. This should form a major function of the management development program being designed by Dunn, Harnden, and Maher.

IV. Suggestions for Additional Research

It is appropriate at this point to recall that this study was designed as part of a larger project by Dunn et al. which had as its overall aim the development of an experimental management development

program for research and development project selection decision makers. Accordingly, in terms of the overall aim of the project, much research remains to be done.

However, this study has uncovered a need for additional research beyond that envisaged at the outset.

1. Data Base

Size and ownership information should be obtained for all firms. The completion of this data base will permit more detailed and complete analysis, particularly with respect to smaller firms. This work could be done either by use of a supplementary questionnaire or by a telephone poll.

2. Ownership

The situation noted earlier in which ownership was found to correlate significantly with size but not with sophistication could be investigated by segmenting the data on the basis of size and then carrying out crosstabulations between ownership and variables describing sophistication. Other segmentation/ crosstabulation combinations could be included in the analysis.

3. Size

A research program should be designed to examine why smaller firms tend to be less sophisticated than larger firms and what can/should be done to change

that. In particular the program should identify which smaller firms fall into the various patterns described above and why. This information will be a valuable input to the design of the management development program.

4. Assumption

The assumption that the attitudes and practices reported in the original questionnaire represent those of the parent company could be verified by means of an additional questionnaire mailed to the parent firms of those firms represented in the data base.

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APPENDIX A

CLIMATE FOR TECHNOLOGICAL INNOVATION IN CANADA

SURVEY QUESTIONNAIRE

I. GENERAL INFORMATION

1. What is the official incorporated name and location of your company?

   Name of Company_____

   Location of Company_____

2. What is your position (title) in the organization?

3. In which province(s) is your firm entitled to conduct business? Please check (√).

a) All Provinces	___	g) Quebec	___
b) British Columbia	___	h) New Brunswick	___
c) Alberta	___	i) Nova Scotia	___
d) Saskatchewan	___	j) Prince Edward Island	___
e) Manitoba	___	k) Newfoundland	___
f) Ontario	___	l) The Territories	___

4) Does your firm [illegible] products or services internationally? Yes____ No____

5) Would you please indicate (√) the major industrial classification(s) to which your firm belongs.

a) Agriculture	___	i) Retail Trade	___
b) Forestry	___	j) Wholesale Trade	___
c) Mining	___	k) Finance	___
d) Manufacturing	___	l) Insurance	___
e) Construction	___	m) Real Estate	___
f) Transportation	___	n) Service	
g) Communication	___	o) Public Administration	___
h) Utilities	___	p) Defense	___

6) Would you please indicate (√) whether your firm is solely engaged in Research and Development or whether Research and Development activities are part of a larger corporate structure.

   a) Solely Research and Development ____

   b) Research and Development is part of corporate structure ____

7) Please indicate (√) the way in which your Research and Development activities are organized.

   a) Pure Research and Development ____

   b) Applied Research and Development ____

   c) Mix of Pure and Applied Research and Development ____

   d) Other (would you please briefly describe below?) ____

_____

_____

_____

_____

II. PRODUCT DEVELOPMENT

Terminology used in the following section of the questionnaire

(1) Management Determination of product fields and markets of primary interest.

(2) Exploration - the search for new product ideas which meet company objectives.

(3) Screening - quick analysis to determine which ideas warrant investigation.

(4) Business Analysis - the expansion of an idea, through creative analysis, into a concrete business recommendation including product features and a program.

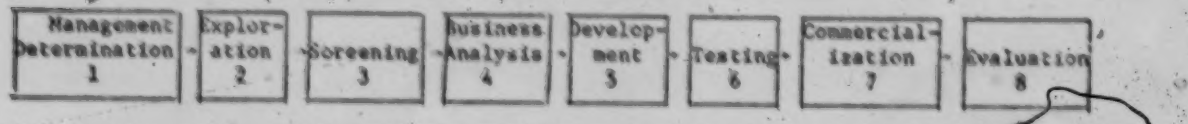
(5) Development - turning the idea-on-paper into a product-in-hand.

(6) Testing - the commercial experiments necessary to verify early business judgments

(7) Commercialization - launching the product in full-scale production and sale.

(8) Evaluation - post-introduction evaluation to determine whether to continue or drop the new product.

Schematic - the following schematic represents one possible corporate alignment of work flow for management of new products.



8. Would you please indicate (√) at what point(s) in the above schematic marketing personnel are brought into the product innovation stream and what level of management is brought in.

Schematic Number	Marketing Personnel Brought in	Marketing Personnel Not Brought in	Level of Management Brought in: Top	Middle	Line	Other (e.g. Consultants) (please specify)
1						
2						
3						
4						
5						
6						
7						
8						

9. Would you please indicate (√) the degree of influence marketing personnel have when they are brought into the product innovation stream.

No Influence ——— ——— ——— ——— ——— ——— ——— Total Influence

10. Would you please indicate (√) at what point(s) in the above schematic marketing personnel should be brought into the product innovation stream and what level of management should be brought in.

Schematic Number	Marketing Personnel Should be Brought in	Marketing Personnel Not Brought in	Level of Management Should be Brought in: Top	Middle	Line	Other (e.g. Consultants) (please specify)
1						
2						
3						
4						
5						
6						
7						
8						

11. Would you please indicate (√) the degree of influence marketing personnel should have when they are brought into the product innovation stream.

No Influence ——— ——— ——— ——— ——— ——— ——— Total Influence

III. RESEARCH AND DEVELOPMENT PROJECT SELECTION

12. Does your firm use Research and Development project selection techniques? Yes___ No___

13. Would you please indicate (✓) below whether your firm is currently using, has used in the past, plans to use in the future, or has never used the following Research and Development project selection techniques.

Terminology

a) Ranking Models where the decision maker compares one project with another or a grouping of projects and selects which he prefers.

b) Scoring Models which compute an overall project score based on rating of the project against preselected critical criteria.

c) Economic Models which employ calculations such as net present value, internal rate of return, or economic equations.

d) Constrained Optimization Models which attempt to optimize an economic objective function subject to specific resource constraints.

e) Risk Analysis Models which are based on a simulation analysis of input data in distribution form.

TECHNIQUES	used for past 2 years	used for past 2-5 years	used for longer than 5 years	plan to use in future	have never used	used but discarded (Give year discarded)
a) Ranking Models						
b) Scoring Models						
c) Economic Models						
d) Constrained Optimization Models						
e) Risk Analysis Models						

14. If your firm is not using any of the above Research and Development project selection techniques would you make a brief statement as to why this is so.

_____

_____

_____

_____

15. Is your firm satisfied with its present procedures for selection of Research and Development projects?

Yes_____ No_____

16. Do present procedures used for the selection of Research and Development projects involve the use of probability estimates for technical and/or commercial success?

a) For technical success Yes_____ No_____

b) For commercial success Yes_____ No_____

17. Are specific Research and Development projects selected from multiple proposals or are they looked at one at a time?

a) From multiple proposals Yes_____ No_____

b) Looked at one at a time Yes_____ No_____

18. Please describe briefly steps taken by your firm to stimulate the generation of Research and Development and/or New Product ideas.

_____

_____

_____

_____

_____

19. What factors are used by your firm to evaluate Research and Development projects? Please check (✓).

a) Research and Development
- Likelihood of technical success
- Development cost
- Development time
- Capability of available skills
- Availability of R&D resources
- Availability of R&D facilities
- Patent status
- Compatibility with other projects

b) Manufacturing
- Capability of manufacturing product
- Facility and equipment requirements
- Availability of raw material
- Manufacturing safety

c) Corporate Objectives
- Fits into overall objectives and strategy
- Corporate image

d) Financial
- Profitability
- Capital investment required
- Annual (or unit) cost
- Rate of return on investment
- Unit price
- Payout period
- Utilization of assets, cost trend, cost reduction, and cash flow

e) Timing
- Timing of introduction of new product
- Expected product sales life

f) Marketing and Distribution
- Size of potential market
- Capability to market product
- Market trend and growth
- Customer acceptance
- Relationship with existing markets
- Market share
- Market risk during development period
- Pricing: trend, propriety problem, geographical extent, and effect on existing products
- Complete product line and quality improvement

20. Would you please indicate (✓) whether there have been changes in corporate objectives, corporate control systems, corporate structure, professional development of Research and Development personnel, and type of information in the data base during the specified time periods.

	during past 2 years	during past 2-5 years	longer than 5 years	no change
a) Changes in objectives				
- Financial				
- Production				
- Marketing				
b) Changes in corporate control systems				
- Financial				
- Production				
- Marketing				
c) Changes in corporate structure				
- More centralized structure				
- More decentralized structure				
- Moved from line-staff to a program management structure				
d) Changes in professional development opportunities for Research and Development Personnel				
- Increased opportunity for professional development				
- Decreased opportunity for professional development				
e) Changes in sources or type of information included in the data base used for the selection of Research and Development projects				
- Changes in source				
- Changes in type				

21. Given your response to question 20 above, to what degree does your firm agree with the following statements regarding the impact of the changes on the morale of Research and Development personnel and on the output of the Research and Development unit. Please check (✓).

	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
a) The changes in the following areas have led to increased morale of Research and Development personnel					
- Changes in objectives	___	___	___	___	___
- Changes in corporate control systems	___	___	___	___	___
- Moved toward a more centralized structure	___	___	___	___	___
- Moved toward a more decentralized structure	___	___	___	___	___
- Moved to a program structure	___	___	___	___	___
- Increased professional development opportunity	___	___	___	___	___
- Decreased professional development opportunity	___	___	___	___	___
- Changed sources of information	___	___	___	___	___
- Changed type of information	___	___	___	___	___
b) The changes in the following areas have led to increased output from the Research and Development unit					
- Changes in objectives	___	___	___	___	___
- Changes in corporate control systems	___	___	___	___	___
- Moved toward a more centralized structure	___	___	___	___	___
- Moved toward a more decentralized structure	___	___	___	___	___
- Moved to a program structure	___	___	___	___	___
- Increased professional development opportunity	___	___	___	___	___
- Decreased professional development opportunity	___	___	___	___	___
- Changed sources of information	___	___	___	___	___
- Changed type of information	___	___	___	___	___

22. To what degree does your firm agree with the following statements? Please check (✓).

	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
a) Formal decision processes help in logically consistent decisions	___	___	___	___	___
b) Formal decision processes allow research management to more clearly identify those projects or ideas which are well worth investing time and money in and those which are not	___	___	___	___	___
c) Formal decision processes allow termination of unsuccessful projects at the earliest possible time	___	___	___	___	___
d) Formal decision processes make managers aware of information that should be acquired when making decisions on projects or ideas	___	___	___	___	___
e) The primary objective of using formal decision processes is to make decisions for managers	___	___	___	___	___
f) The primary objective of using formal decision processes is to aid managers in making decisions	___	___	___	___	___

23. Who in your organization makes decisions regarding the following types of Research and Development programs?

	Person and/or group in organization
a) Exploratory Research and Development Programs	
b) High risk business development Research and Development programs	
c) Support of existing business Research and Development programs	

24. Do considerations of scientific break-throughs internal or external to your firm influence funding patterns for Research and Development activities?

Yes____ No____

25. Do you have some intuitive or operational criteria for the identification of a "good funding pattern?"

Yes_____ No_____

IV. TECHNOLOGICAL FORECASTING

26. Does your organization use technological forecasting techniques? Yes_____ No_____

27. Would you please indicate (✓) below whether your firm is currently using, has used in the past, plans to use in the future, or has never used the following techniques in connection with Research and Development selection and/or Product Development.

TECHNIQUES	used for past 2 years	used for past 2-5 years	used for longer than 5 years	plan to use in future	have never used	used but discarded (Give year discarded)
a) Extrapolative Approaches						
b) Morphological Analysis						
c) Scenario Writing						
d) Impact Analysis						
e) Relevance Analysis						
f) Contextual Mapping						
g) Normex Reconciliation						
h) Delphi Method						
i) SOON Charting						
j) Technological Mission Analysis						

28. When considering Research and Development projects does your firm consider the following questions? Please check (✓).

	Yes	No
a) Is Research and Development consistent with corporate strategy?		
b) Should we invest in the same technologies as our competition?		
c) How do we maximize the flexibility of our organization structure in the face of rapid technological change?		
d) How can technology transfer best be achieved from Research and Development to Manufacturing and Marketing?		
e) What kind of product/market strategy should we follow?		
f) What technical advantages in our products, at what cost, will be needed in the future to give us a substantial competitive advantage?		

29. Does your firm have a specific strategy for internal integration of technological forecasting?

Yes_____ No_____

V. MANAGEMENT GAMES OR SIMULATION

30. Does your firm use computers in any aspect of its operation? Yes_____ No_____

31. Has your firm any experience in adopting and implementing a "decision information system" computerized or other?

a) Computerized Yes_____ No_____

b) Other (please specify) Yes_____ No_____

_____

_____

32. Has your firm ever used a management game or simulation in Research and Development selection and/or Product Development?

Yes_____ No_____

a) If yes, please describe briefly the area(s) in which a game or simulation was utilized.

_____

_____

_____

b) Was the game or simulation computerized? Yes_____ No_____

c) Was it successful? Yes_____ No_____

33. Has your firm ever used a management game or simulation in any part of its planning activity other than Product Development and Research and Development?

Yes_____ No_____

a) If yes, please describe briefly the area(s) in which a game or simulation was utilized.

_____

_____

_____

b) Was the game or simulation computerized? Yes_____ No_____

c) Was it successful? Yes_____ No_____

34. As indicated in the covering letter we are interested in further in-depth analysis in order to build a management game or simulation model that can be used both experimentally and as an aid for helping project managers learn about techniques that are useful in the project selection decision.

a) Would your firm, if selected, be willing to participate in on-site interviews (conducted at our expense)?

Yes_____ No_____

b) If current research is successful, would your firm be willing to participate in such an experimental management game or simulation?

Yes_____ No_____

APPENDIX B
EXAMPLE OF DATA DECK AND QUESTIONNAIRE REFERENCES

QUESTIONNAIRE REF.	FIRM	CARD NO.	LOCATION OF FIRM 2	3	4	5	6a	6b	6c	7	8a	8b	8c	9	10a	10b	10c
DATACARD	0011	01	1	13	1	14	102			02	22212121	00000000	00014400	4	11212101	22217664	00000000

QUESTIONNAIRE REF.	FIRM	CARD NO. 11	12	13	14	15	16	17	18	19	20a	20b	20c	20d	20e
DATACARD	0012	51		15230	01	2	220	122	01	11111110000111100001100111100010	112	144	100	44	14

QUESTIONNAIRE REF.	FIRM	CARD NO.	21a	21b	22a-f	23	24	25	26	27a-i	28a-f	29	30	31	32	33	34a-b
DATACARD	0013		220000020	220000040	224224	111	2	2	2	1551555555	222111	2	2	220	2000	0000	11

QUESTIONNAIRE REF.	FIRM	CARD NO.	SALES IN 1972	OWNER IN 1969
DATACARD	0014		00001	6

APPENDIX C

List of Variables

Variable #	Description	Question #
VAR001	Location of Firm	1
VAR002	Position in Firm	2
VAR003	Geographic Area of Business	3
VAR004	International Markets	4
VAR005	Industrial Classification	5
VAR006	Soley Research and Development	6(a)
VAR007	Research and Development is Part of Corporate Structure	6(b)
VAR008	Both Kinds of Research and Development	6(a and b)
VAR009	Organization of Research and Development	7
VAR010	Marketing I	8
VAR011	Marketing II	8
VAR012	Marketing III	8
VAR013	Marketing IV	8
VAR014	Marketing V	8
VAR015	Marketing VI	8
VAR016	Marketing VII	8
VAR017	Marketing VIII	8
VAR018	Management I	8
VAR019	Management II	8
VAR020	Management III	8
VAR021	Management IV	8
VAR022	Management V	8

Variable #	Description	Question #
VAR023	Management VI	8
VAR024	Management VII	8
VAR025	Management VIII	8
VAR026	Consultant I	8
VAR027	Consultant II	8
VAR028	Consultant III	8
VAR029	Consultant IV	8
VAR030	Consultant V	8
VAR031	Consultant VI	8
VAR032	Consultant VII	8
VAR033	Consultant VIII	8
VAR034	Marketing Personnel Influence	9
VAR035	Marketing Should I	10
VAR036	Marketing Should II	10
VAR037	Marketing Should III	10
VAR038	Marketing Should IV	10
VAR039	Marketing Should V	10
VAR040	Marketing Should VI	10
VAR041	Marketing Should VII	10
VAR042	Marketing Should VIII	10
VAR043	Management Should I	10
VAR044	Management Should II	10
VAR045	Management Should III	10
VAR046	Management Should IV	10
VAR047	Management Should V	10
VAR048	Management Should VI	10
VAR049	Management Should VII	10
VAR050	Management Should VIII	10
VAR051	Consultants Should I	10
VAR052	Consultants Should II	10
VAR053	Consultants Should III	10
VAR054	Consultants Should IV	10

Variable #	Description	Question #
VAR055	Consultants Should V	10
VAR056	Consultants Should VI	10
VAR057	Consultants Should VII	10
VAR058	Consultants Should VIII	10
VAR059	Marketing Influence Should Be	11
VAR060	Research and Development Project Selection Techniques	12
VAR061	Ranking Models	13(a)
VAR062	Scoring Models	13(b)
VAR063	Economic Models	13(c)
VAR064	Constrained Optimization Models	13(d)
VAR065	Risk Analysis Models	13(e)
VAR066	Why No Research and Development Selection Techniques	14
VAR067	Present Research and Development Procedures OK	15
VAR068	Probability Estimates of Technical Success	16(a)
VAR069	Probability Estimates of Commercial Success	16(b)
VAR070	Probability Estimates of Technical and Commercial Success	16 (a and b)
VAR071	Projects Selected From Alternatives	17(a)
VAR072	Projects Selected Individually	17(b)
VAR073	Mixed Project Selection	17 (a and b)
VAR074	Steps in Research and Development Generation	18
VAR075	Probability of Technical Success	19(a)
VAR076	Development Cost	19(a)
VAR077	Development Time	19(a)
VAR078	Availability of Skills	19(a)
VAR079	Availability of Research and Development Resources	19(a)

Variable #	Description	Question #
VAR080	Availability of Research and Development Facilities	19(a)
VAR081	Patent Status	19(a)
VAR082	Project Compatibility	19(a)
VAR083	Consistency of Project With Policies	19(c)
VAR084	Corporate Image	19(c)
VAR085	Profitability	19(d)
VAR086	Required Capital	19(d)
VAR087	Annual Cost	19(d)
VAR088	Rate of Return on Investment	19(d)
VAR089	Unit Price	19(d)
VAR090	Payout Period	19(d)
VAR091	Asset Utilization	19(d)
VAR092	Timing of Introduction	19(e)
VAR093	Sales Life	19(e)
VAR094	Manufacturing Capability	19(b)
VAR095	Facilities and Equipment Required	19(b)
VAR096	Raw Materials Availability	19(b)
VAR097	Manufacturing Safety	19(b)
VAR098	Market Potential	19(f)
VAR099	Marketing Capability	19(f)
VAR100	Market Trends	19(f)
VAR101	Customer Acceptance	19(f)
VAR102	Relationship With Existing Markets	19(f)
VAR103	Market Share	19(f)
VAR104	Market Risk	19(f)
VAR105	Pricing	19(f)
VAR106	Product Lines	19(f)
VAR107	Changes in Financial Objectives	20(a)
VAR108	Changes in Production Objectives	20(a)

Variable #	Description	Question #
VAR109	Changes in Marketing Objectives	20(a)
VAR110	Changes in Financial Controls	20(b)
VAR111	Changes in Production Controls	20(b)
VAR112	Changes in Marketing Controls	20(b)
VAR113	More Centralization	20(c)
VAR114	More Decentralization	20(c)
VAR115	From Line-Staff to Program Management	20(c)
VAR116	Increased Professional Development	20(d)
VAR117	Decreased Professional Development	20(d)
VAR118	Changed Data Source	20(e)
VAR119	Changed Data Type	20(e)
VAR120	Improved Morale--Changed Objectives	21(a)
VAR121	Improved Morale--Changed Control Systems	21(a)
VAR122	Improved Morale--Centralization	21(a)
VAR123	Improved Morale--Decentralization	21(a)
VAR124	Improved Morale--Changed to Program Structure	21(a)
VAR125	Improved Morale--Increased Professional Development	21(a)
VAR126	Improved Morale--Decreased Professional Development	21(a)
VAR127	Improved Morale--Changed Sources of Information	21(a)
VAR128	Improved Morale--Changed Type of Information	21(a)
VAR129	Improved Productivity--Changes in Objectives	21(b)
VAR130	Improved Productivity--Changes in Control Systems	21(b)
VAR131	Improved Productivity--Centralization	21(b)

Variable #	Description	Question #
VAR132	Improved Productivity--Decentralization	21(b)
VAR133	Improved Productivity--Changed to Program Structure	21(b)
VAR134	Improved Productivity--Increased Professional Development	21(b)
VAR135	Improved Productivity--Decreased Professional Development	21(b)
VAR136	Improved Productivity--Changed Sources of Information	21(b)
VAR137	Improved Productivity--Changed Type of Information	21(b)
VAR138	Formal Decision Processes Help--Logical Decisions	22(a)
VAR139	Formal Decision Processes Help--Clarity	22(b)
VAR140	Formal Decision Processes Help--Pruning	22(c)
VAR141	Formal Decision Processes Help--Required Information	22(d)
VAR142	Formal Decision Processes Help--Make Decisions	22(e)
VAR143	Formal Decision Processes Help--Aids Decisions	22(f)
VAR144	Decider--Exploratory Research and Development	23(a)
VAR145	Decider--High Risk Research and Development	23(b)
VAR146	Decider--Support of Existing Research and Development	23(c)
VAR147	Do Breakthroughs Influence Funding Patterns	24
VAR148	Criteria for Funding Patterns	25
VAR149	Use of Technological Forecasting	26
VAR150	Technological Forecasting--Extrapolative	27(a)

Variable #	Description	Question #
VAR151	Technological Forecasting--Morphological Analysis	27(b)
VAR152	Technological Forecasting--Scenario Writing	27(c)
VAR153	Technological Forecasting--Impact Analysis	27(d)
VAR154	Technological Forecasting--Relevance Analysis	27(e)
VAR155	Technological Forecasting--Contextual Mapping	27(f)
VAR156	Technological Forecasting--Normex Reconciliation	27(g)
VAR157	Technological Forecasting--Delphi Method	27(h)
VAR158	Technological Forecasting--Soon Charting	27(i)
VAR159	Technological Forecasting--Technological Mission Analysis	27(j)
VAR160	Project Selection--Research and Development Consistency	28(a)
VAR161	Project Selection--Technology of Competitors	28(b)
VAR162	Project Selection--Flexibility	28(c)
VAR163	Project Selection--Technology Transfer:Research and Development to Marketing	28(d)
VAR164	Project Selection--Product/Market Strategy	28(e)
VAR165	Project Selection--Technical Advantage	28(f)
VAR166	Plan for Integration of Technological Forecasting	29
VAR167	Computers Used in Operations	30
VAR168	Experience in Computerized Decision Information Systems	31(a)
VAR169	Experience in Other Decision Information Systems	31(b)
VAR170	Other Decision Information Systems	31(b)

Variable #	Description	Question #
VAR171	Games Used in Research and Development	32
VAR172	Area Game Used in Research and Development	32(a)
VAR173	Game Computerized (Research and Development)	32(b)
VAR174	Game Successful (Research and Development)	32(c)
VAR175	Games Used Otherwise	33
VAR176	Other Use of Games	33(a)
VAR177	Game Computerized (Other)	33(b)
VAR178	Game Successful (Other)	33(c)
VAR179	Interviews Consent	34(a)
VAR189	Game Participation Consent	34(b)
VAR181	Sales in 1972	New Data
VAR182	Ownership in 1969	New Data